Parametric dependence and control of 3D helical structures in MST

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Outline

• Ip dependence of mode spectra
• Emergence of central 3D structure
• S dependence of mode spectra
• Confinement improvement
RFP equilibrium provides many resonant surfaces

When helical structure occurs, associated with innermost mode.
At low $I_p$, mode spectra fairly flat

$n = 6-10$

$n = 5$

$\frac{b}{B(a)} \sim 1\%$

$I_p = 0.18 \text{ MA}$
At high $I_p$, mode spectra are $\sim$ single helicity

$n = 5$

$b/B(a) \sim 7\%$

$n = 6-10$

$I_p = 0.6$ MA
With single helicity spectra, core is helical

- Structure detected internally with Faraday rotation, Bergerson et al., PRL
Can now routinely “dial up” large mode

- Keys are low density, $B_t(a) \sim 0$, sustained toroidal loop voltage
In RFX-mod, spectra depend on $S$ and $I_p$ (RFX-mod) 0.5 - 1.6 MA. 

The graph shows $b_\phi / B(a)$ (●) and $b_\phi^{1, secd} / B(a)$ (◇) as functions of the Lundquist number $S$, which is approximately $I_p T_e^{3/2} / n_i^{1/2}$. The $x$-axis represents $S$, and the $y$-axis represents $b_\phi / B(a)$ with values ranging from 1 to 4. The data points for $b_\phi^{1, secd} / B(a)$ are also plotted, showing a similar trend.
MST may exhibit similar spectral dependence

\( I_p (RFX-mod) \)

0.5 - 1.6 MA

\( b_\phi / B(a) \) (%)

0.6 MA (MST)

0.18 MA (MST)

\( b_0^{1,-7} / B(a) \)

\( b_0^{1,\text{secd}} / B(a) \)

\( S, \text{ Lundquist number} \sim I_p T_e^{3/2} / n_i^{1/2} \)
Te increases substantially in the core

- Global energy confinement time likely improved several fold
Summary

• Helical structure in otherwise axisymmetric plasmas
• Spectral dependence on Ip and S
• Increased central Te, improved confinement